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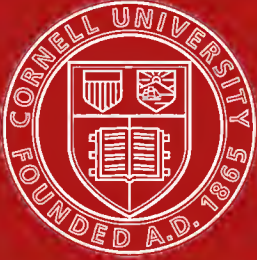


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MINISTRY OF FINANCE, EGYPT.

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Egypt. SURVEY DEPARTMENT

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# DISINTEGRATION AND PRESERVATION OF BUILDING STONES IN EGYPT.

BY

A. LUCAS, F.I.C.

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## PREFACE.

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The present note is a second and revised edition of a small pamphlet entitled "The Disintegration of Building Stones in Egypt," published by the writer in 1902.

The subject of the corrosion and protection of building stones in Egypt is one of considerable importance, and as the nature of the corrosion is peculiar to the country, the literature dealing with stone corrosion elsewhere is of very little use.

The matter has been made as little technical as possible.

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# THE DISINTEGRATION AND PRESERVATION OF BUILDING STONES IN EGYPT.

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## INTRODUCTION..

The principal destructive agent which attacks and destroys the stone used in buildings in large towns in England, on the Continent of Europe, and in America, is sulphuric acid, formed by the oxidation, during combustion, of the sulphur compounds which are always present in coal and coal gas. This acid is subsequently dissolved out of the atmosphere and brought into contact with the stone by means of rain.

Other agents of destruction, which, however, operate to a far less extent than sulphuric acid, are as follows :—

1.—Variations of temperature, which produce alternate expansion and contraction, whereby stresses are set up, which cause the outer surfaces of the stone to crack and peel off.

2.—Frost, which by solidifying any water contained in the pores of the stone, produces considerable expansion and disruption.

3.—The mechanical action of wind-borne particles of sand, producing abrasion.

4.—The mechanical action of water, such as rain driven against the surface of the stone, which also produces abrasion.

5.—The solvent action of water containing carbon dioxide and other substances in solution. This is especially marked in the case of limestone.

The different destructive agencies just enumerated are productive of greater damage if the surface of the stone has already been attacked and partly disintegrated by means of sulphuric acid. In Egypt the action of sulphuric acid on building stone is a negligible

quantity. This is chiefly because there are neither large manufacturing towns nor any great domestic use of coal or coal gas, and hence as yet the atmosphere is comparatively pure. Another reason, however, is because this acid, where it is formed, is dispersed before it can cause any damage, the opportunities for it to be carried into the stone being so few on account of the very limited rainfall.

In Egypt frost also is practically absent, and owing to the small amount of rain, the effects of both the mechanical action and the solvent action of water are very small and may be disregarded. The temperature variations, however, are much greater in Egypt than in England or Europe, and the abrasion by sand is also probably greater, but it is to neither of these causes that the very marked disintegration of building stone that occurs in Egypt is due. The cause is one peculiar to the climate, and though doubtless existing in other countries where similar climatic conditions prevail, it is absolutely unknown, and would be impossible, in countries where there is much rain. This special form of disintegration will now be described.

## NATURE OF THE DISINTEGRATION.

One of the most noticeable features about the disintegration is that it occurs most frequently within a zone situated between ground level and a distance of about a metre or a metre and a half above ground level, and that it is generally accompanied by a very marked white incrustation or efflorescence. This efflorescence as a rule consists essentially of sodium chloride, but sometimes is a mixture of sodium chloride and sodium sulphate, and occasionally contains small proportions of other salts, such as sodium carbonate, sodium nitrate, potassium nitrate, etc.

In the case of disintegration occurring near the ground level on walls that have been plastered, large pieces of the plaster are generally forced bodily away from the wall, and in between the wall and the plaster there is a considerable efflorescence of soluble salts. In particularly bad cases this efflorescence takes the form of a thin sheet of almost pure sodium chloride, which may be one or even two millimetres in thickness, and occasionally small cavities in the mortar or in the stone, or between the plaster and the stone, are found filled with a powdery mass of crystals of sodium chloride. Where the

whole surface of the stonework of a structure is disintegrating, an efflorescence is not usually noticeable, but this nevertheless exists, and its presence may readily be demonstrated. In such cases the salts, although in sufficient amount to cause mischief, are not in large enough quantity to be easily visible on the white or grey surface of the stonework. Occasionally only one or more stones in a wall, otherwise good, decay, and here too the decay is due to an efflorescence of soluble salts.

The disintegration most frequently occurs on limestone, but sandstone is by no means exempt, a notable instance where this has been attacked being the temples of Philæ. The circumstances in the case of Philæ, however, were very unusual and will be described later.

### CAUSE OF THE DISINTEGRATION.

The disintegration is entirely a physical and not a chemical phenomenon, and is caused by the crystallization of various salts, chiefly sodium chloride, underneath the surface layers of the stone. For such crystallization to take place three conditions are necessary: first the presence of water-soluble salts, secondly the presence of water to dissolve the salts, and thirdly opportunity for the salts to be brought to the surface of the stone and there to crystallize out by the evaporation of the water holding them in solution.

The whole process is well illustrated by some experiments which will now be described and which were made in order to reproduce, under known conditions, a surface disintegration of stone similar to that occurring naturally. For this purpose a number of cubes of limestone of several different qualities were placed on sand contained in porcelain dishes, and the sand was moistened from time to time, either with distilled water or with a dilute solution of sodium chloride, sodium sulphate, sodium carbonate, sodium nitrate, or calcium sulphate. The experiments lasted in some instances three months and in other instances five months. At the end of that time surface disintegration was produced in most cases, and was accompanied by an efflorescence of the particular salt employed. In those experiments in which there was little or no corrosion, the stone was hard and dense, and in several cases so slightly porous that in three months the water had not been able to mount to the top of a five-centimetre

cube. The experiment in which there was most corrosion was that in which sodium carbonate was the salt employed. In this case a considerable efflorescence quickly formed on the faces of the cube, and in several places thin layers of the stone were very soon partly forced off by a growth of crystals underneath, and after about a month, a stencilled number, which was originally on the stone, was standing out at a distance of seven millimetres from the surface, and had ceased to be in contact with the stone at any one point, being merely held in position by the crystalline growth. This eventually fell away, carrying the detached layer of the stone with it, and, on adding water, the crystals dissolved, leaving the stencilled number exposed at the bottom of the dish.

The following table summarizes the details and results of the experiments :—

CHARACTER OF LIMESTONE.	Soluble Salts in Stone.	Soluble Salts in Sand.	Duration of Experi- ments.	Solution used to moisten Sand	Result.
	Per cent.	Per cent.	Months.		
Soft and porous ... ..	0·62	0·07	5	Distilled water	Corrosion.
Soft and porous ... ..	0·19	0·07	5	„	Corrosion.
Fairly hard and dense...	0·30	0·24	5	Sodium chloride	Corrosion.
Soft and porous ... ..	0·36	0·24	5	Sodium nitrate	Corrosion.
Fairly hard and dense ..	0·39	0·24	5	Sodium carbonate	Much Corrosion.
Hard and dense ... ..	—	0·24	3	Distilled water	<i>Nil.</i>
Hard and dense ... ..	—	0·24	3	„	<i>Nil.</i>
Soft and porous ... ..	—	0·24	3	Calcium sulphate	Slight Corrosion.
Fairly hard and dense...	—	0·24	3	Sodium carbonate	Much Corrosion.
Hard and dense ... ..	—	0·24	3	Sodium sulphate	<i>Nil.</i>

The three conditions mentioned as being necessary for the production of disintegration will now be considered in detail. They are firstly salts, secondly water, and thirdly opportunity for the salts to be brought to the surface of the stone, and for the water holding them in solution to evaporate.

## SALTS.

The salts responsible for the disintegration of building stone in Egypt are derived either from the stone itself or from the ground. These two sources will now be considered.

### SALTS IN THE STONE.

The principal building stones occurring in Egypt are limestone, sandstone, quartzite, and granite:—

*Limestone.*—Limestone was rarely used by the ancient Egyptians, and, except for the Pyramids and Sphinx, most of the old buildings and monuments were built of either sandstone or granite. \* Limestone, however, on account of its abundance and accessibility, and also, and more especially, because it is soft and easily worked, is almost the only building stone employed in modern Egypt.

A large number of samples of limestone from the quarries to the east and south-east of Cairo have been examined for soluble salts, with the results shown in the following table. The salts were principally sodium chloride.

NUMBER OF SAMPLES EXAMINED.	WATER-SOLUBLE SALTS.		
	Highest.	Lowest.	Mean.
	Per cent.	Per cent.	Per cent.
132	4·64	0·12	0·52

*Sandstone.*—Although used extensively by the ancient Egyptians for their temple buildings, sandstone is practically never employed

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\* The third pyramid at Giza, although of limestone, was faced with granite, part of which facing still remains.

at the present time for building purposes in Egypt. This is partly because the situation of the quarries in Upper Egypt makes the cost of sandstone higher than that of limestone, but probably more particularly because sandstone is not so easily dressed as limestone. A few samples of sandstone from the Silsila \* and Girtass † quarries, which were worked in former times, have been examined for soluble salts, with the following results:—

NUMBER OF SAMPLES EXAMINED.	WATER-SOLUBLE SALTS.		
	Highest.	Lowest.	Mean.
	Per cent.	Per cent.	Per cent.
17	0·29	0·03	0·14

*Quartzite.*—Quartzite from Gebel Ahmar, near Cairo, is occasionally employed for the lower courses of buildings; it was also used in the reconstruction of the regulator at the Menufia head of the Delta Barrage. One sample examined was found to contain 0·16 per cent of water-soluble salts.

*Granite.*—With the exception of that used for the Aswân Dam, and a small amount used for the piers and abutments of the Bulâq Bridge, Cairo, practically no local granite has been employed for building purposes in Egypt for several thousands of years, although it was extensively used by the ancient Egyptians. Scotch, Swedish, and Corsican ‡ granite, however, have all been employed to a small extent. No samples of granite have been examined for soluble salts, but the amount present is certainly very small.

#### SALTS IN THE SOIL.

Although in some cases the salts which destroy building stone in Egypt come wholly from the stone itself, yet in the greater proportion of instances the salt comes from the ground, and this is the

\* About sixty-eight kilometres north of Aswân.

† About forty kilometres south of Aswân.

‡ Corsican granite was used for the visible masonry of the new English Bridge, Cairo.



chief reason why the zone of disintegration is so frequently found close to the ground level.

A number of samples of surface soil from Cairo and neighbourhood, taken either from the vicinity of buildings or from building sites, have been examined for soluble salts, with the following results :—

NUMBER OF SAMPLES EXAMINED.	WATER-SOLUBLE SALTS.		
	Highest.	Lowest.	Mean.
	Per cent.	Per cent.	Per cent.
19	20·26	0·47	5·46

### WATER.

So far as the zone of disintegration of building stone which occurs just above ground level is concerned, the chief source of the water, as of the salts, is the ground, and the water is principally that naturally present, but frequently augmented by that employed for watering the garden and paths immediately adjoining the building or wall that suffers.

In the case of the disintegration occurring in positions not near ground level, the moisture comes partly from rain, but more generally from morning mist, and this latter is especially the case where stonework adjoins the river or the sea.

### METHOD OF PRESERVATION.

In this, as in other matters, “prevention is better than cure,” and the fact that the stonework of a building requires preservation is in itself a condemnation of the material employed.

For all works of importance, a hard dense stone, as little porous as possible, is essential if subsequent damage and disfigurement are to be avoided. Such a stone will contain a minimum of soluble salts, and will afford a minimum penetration for water, and a maximum resistance to disintegration. An efficient damp course is also essential. For such constructions as bridges, regulators, quay walls, etc., where a damp course would be useless on account of the fluctuations

of water level, the use of a hard dense stone with a minimum porosity is still more necessary, and such a stone may almost be regarded as in itself a damp course, as it does not readily absorb or transmit either water or soluble salts.

For stonework permanently under water the matter is somewhat different, and if the stone is strong enough and suitable in other respects, the presence of soluble salts is of secondary importance (except in so far as much salt is frequently an indication of a generally inferior stone), provided the salts are not present in the form of definite veins in the stone.\* When a stone containing soluble salts is placed permanently under water, it becomes impossible for the salts to concentrate and crystallize at the surface, where alone they can cause damage, and they are gradually dissolved out and carried away.

In many cases, however, the question is one, not of prevention, but of cure, and this will now be considered. Theoretically it should be possible to retard disintegration and to avoid further damage in any of the following four ways, namely:—

1.—By removing the salts.

2.—By preventing moisture from gaining access to the stone, as without moisture the salts are harmless.

3.—By preventing any solution of salts formed in the stone from reaching the surface.

4.—By so hardening the surface of the stone that the crystallization of the salts will not disintegrate it.

These four possibilities will now be considered.

### 1.—*Removing the Salts.*

The most efficient way of getting rid of the salts would be to soak the stone for a considerable period in running water, but ordinarily this method is quite impracticable. Any partial washing of the

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\* I have seen limestone which fell to pieces when soaked in water, owing to its containing definite veinlets of common salt.

stone is worse than useless, as it merely drives the salts from one place to another, and chiefly inwards, to reappear again at the surface when the stone dries.

The salts, however, gradually accumulate at the surface of the stone, and each time the stone scales naturally, or is brushed or scraped intentionally, a certain proportion of the salts are disposed of. This process could be hastened by periodically wetting the stone, allowing it to dry, and then brushing or scraping the surface.

The length of time it would take to get rid of all the salts in the stonework of a building in this manner would naturally depend upon the amount originally present, but in many cases so much of the stone would be removed in the process as to make the remedy worse than the disease. A further objection would be that, since individual stones contain very different proportions of soluble salts, the surface of the stonework would become very uneven and unsightly. Any such remedy would, however, be quite useless where a constant fresh supply of salts could enter the stone from the ground.

From a consideration of the above facts it may be concluded therefore that under ordinary circumstances there is no satisfactory way of removing the salts. There are, however, exceptional cases in which this may be done. Thus, the building of the Aswân Dam and its subsequent heightening provided an excellent illustration of the manner in which injurious salts may enter stonework, the way in which they cause disfigurement and damage, and the way in which, under exceptional circumstances, they may be removed. Before the Aswân Dam was made, the ancient Egyptian temples and buildings on the island of Philæ were all well above the highest flood level of the river, and the stone had not suffered from any disintegration due to soluble salts. After the Dam was finished and the reservoir filled, the buildings were partly submerged for several months each year, Philæ being upstream of the Dam, and water soluble salts, which were present in large amount in the soil of the island, were carried into the stonework of the buildings as the water gradually rose, and finally formed a disfiguring band of white efflorescence just above high water level. This efflorescence caused a certain amount of damage to the surface of the stone, particularly where the stone was inscribed. After the original height of the Dam was increased, most

of the buildings on the island were entirely submerged when the reservoir was full, and in these cases the salts have been gradually washed out of the stone again and carried away, and it is only in a few instances of certain buildings, which are still never entirely submerged, that any efflorescence remains, and in these cases the salts in diminished quantity have been carried higher up to a zone just above the maximum water level.

## 2.—*Preventing the Access of Moisture.*

This is the most important of all, and if it can be accomplished disintegration may be absolutely prevented.

If the damaged stone is situated near the ground level, much of the moisture which gains access is derived, as already stated, from the ground, and this can be prevented from entering the stonework by means of an efficient damp course. In the case of buildings provided with a damp course, and standing in gardens or other enclosures, the soil of the garden or path adjoining the building should on no account be higher than the damp course, otherwise the utility of the latter is much impaired. This is a precaution frequently neglected. The banking of soil against a garden wall, as is frequently done, should also be avoided. When watering the garden or path (the latter practice is very common in Egypt), care should be taken that the base of the building or wall is not watered at the same time. If there should not be any damp course, as is not an uncommon condition in old buildings, and even in enclosure walls of recent date, the soil in the immediate vicinity should on no account be watered, and it would be much better if the garden did not extend to within several metres of the building or wall.

In cases where it is not a question of a zone of disintegration near the base of a wall or building, but a disintegration of the whole surface of the stonework, the moisture responsible for the mischief is, as previously stated, either rain or morning mist or both, but generally the latter, more especially in the immediate vicinity of the river or sea. The entrance of this moisture can only be prevented by making the outer surface of the stonework waterproof.

3.—*Preventing the Salts in Solution within the Stone from reaching the Surface.*

Before the salts contained in a stone can be brought into the condition of solution, water must gain access, and when this is the case there is no practicable way in which the solution formed can be prevented from reaching the surface.

4.—*Hardening the Surface of the Stone.*

This can be done by precipitating certain chemical compounds within the stone, either by combination between the constituents of the stone itself and those of a solution applied to the surface, or by interaction between the ingredients of two separate solutions applied to the stone one after the other. Only a very considerable hardening of the stone to some depth below the surface is of much use, anything short of this resulting in the formation of a thin skin of hardened material which readily scales off.

STONE PRESERVATIVES IN USE.

Any preservative to be of practical value must fulfil at least two conditions. In the first place it must be of such a price that its use on a large scale is economically possible, and secondly it must be capable of easy application in such a way that the stone is well penetrated, and this means in effect that it must be of such a nature that it can be applied by means of a brush or spraying machine.

Before the application of any preservative the surface of the stonework should be well brushed with dry stiff brushes (wire brushes are generally preferable) in order to remove any efflorescent salts or loosely adherent particles of stone. Any preservative, especially if not a water solution, should be applied in the summer, when the stonework is as dry as possible, so that the maximum penetration of the liquid into the pores of the stone may be obtained.

The principal stone preservatives in use will now be described. These may be divided into two main categories, namely, firstly,

waterproofing materials, and secondly chemical compounds which harden the surface of the stone but do not render it waterproof.

The most important waterproofing materials suitable for use on stonework are oil (including oil paint) and wax. Such materials as bitumen, asphalt, tar, pitch, etc., although excellent waterproofing agents for many purposes, cannot be used on buildings (except for damp courses) on account of their colour.

The chemical compounds used to harden stone are very numerous, but the most satisfactory are silicates, silico-fluorides, and baryta.

The preservatives mentioned will now be considered in detail :—

### 1.—*Oil (including Oil Paint).*

Paint is essentially linseed oil, in which a finely ground mineral pigment has been incorporated, the whole being thinned down with turpentine. Paint is perhaps the most common protective coating used for stonework, but it is rarely employed in Egypt as a direct application to the stone, chiefly because there are so few stone buildings of importance that have not been plastered.\* Paint, however, at the best, is a great disfigurement, entirely destroying the special character of the stone, and hence it cannot be used for historical or other buildings of importance, where appearances have to be considered. Paint, too, is perishable and must therefore be renewed every few years.

Linseed oil alone, without pigment, may be used, but it suffers from many of the disabilities of paint, being apt to produce disfigurement and always requiring periodical renewal. Boiled linseed oil, where it ceases to be absorbed by the stone, or where (owing to inequalities either in the stone or in its degree of dryness) it is not absorbed at all, produces glazed patches, which are very unsightly.

Pale boiled linseed oil, or raw oil, causes less disfigurement than boiled oil. Linseed oil should be thinned down with turpentine or benzine before use. Linseed oil is an ingredient of several of the special stone preservatives on the market. From some experiments

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\* The old Egyptian temples and monuments are without plaster, as also many of the older Cairo mosques and various other buildings of about the same date, but most modern buildings, with very few exceptions, are covered with plaster.

made, pale boiled linseed oil thinned down with benzine would appear to be the best. Mineral oil, in the form of a light coloured machine oil, thinned down with benzine, was tried in some experiments, but it was not a success. On the porous limestone used it was absorbed well and imparted to the stone a uniform brown tint which was not at all unpleasing, but on standing the stone in brine, although a very small portion only was submerged, the oil was driven to the surface and gave the stone a greasy and very objectionable appearance.\*

## 2.—*Wax.*

Paraffin wax, both in the solid state and also in solution, has been employed as a stone preservative. In the solid condition (mixed with a little creosote to prevent fungus growths) it was used on the Egyptian obelisk in New York.†

Ceresin, a solid paraffin obtained from ozokerit, has also been used, both alone and in the form of a paste mixed with terpene and toluol.‡

When solid wax is used, the entire face of the stonework to be treated must be heated by special means either before or after the application of the melted wax, and although this is feasible in the case of a single monument, it is not a method that is either very cheap or very easy of application in the case of a large building. Ceresin in solution in petrol has also been tried, but was not a success.†

Paraffin wax in solution is an ingredient of at least one of the special stone preservatives sold.

Beeswax in solution in coal-tar naphtha or turpentine has also been suggested, but it suffers from the same disabilities as paraffin wax, and is more expensive.

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\* The stone was a cube of ten centimetres each way, and this was stood in about three centimetres of brine. After about twenty-four hours a film of oil showed at the water level and a little oil at the top, and after a further twenty-four hours the stone above water level, both top and sides, was covered with oil, and patches of salt efflorescence began to show also on the stone.

† "Stone for Building and Decoration." G. P. Merrill, New York, 1903, pp. 494-495.

‡ "Conservation of Historic Buildings and Frescoes," Prof. A. H. Church, F.R.S., Royal Inst. Lecture, April, 1907.

### 3.—*Silicates.*

The two silicates employed are sodium silicate and potassium silicate; and these are generally sold in the form of very alkaline water solutions.\* These compounds are also frequently put on the market as stone preservatives under various fancy names. These silicates act in several ways: in the first place they partly dry up, leaving colloidal silica in the pores of the stone; in the second place they are slowly decomposed by the carbon dioxide of the air, with the deposition of solid silica; and in the third place, if the stone is limestone, a certain amount of chemical combination takes place between the silicate and the stone itself, giving rise to calcium silicate. All these reactions tend to harden the stone and to make it denser and less porous to the depth penetrated by the solution, but the stone is not waterproofed in any way, despite statements to this effect in certain advertisements.

Sodium silicate has been tried in Egypt, but without success. A certain amount of hardening of the surface of the stone does take place, and possibly disintegration is temporarily arrested to some extent, but the hardened surface soon scales off, leaving the stone in its original condition.

The action of sodium or potassium silicate, when applied to limestone, gives rise to the formation of sodium or potassium carbonate, partly owing to interaction between the silicate and the limestone, and partly to the absorption by the caustic soda or potash of carbon dioxide from the air. The sodium or potassium carbonate thus formed manifests itself as an efflorescence on the surface of the stone, which is the very condition that in Egypt causes disintegration. Sodium silicate is frequently employed in conjunction with a chloride, such as calcium or barium chloride, or with an aluminium compound, such as the sulphate. The stone is first treated with the silicate solution and afterwards with the other compound chosen, when a double decomposition takes place, causing the formation within the stone itself of insoluble calcium, barium, or aluminium silicate (ac-

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\* An aqueous solution of sodium or potassium silicate has an alkaline reaction, owing to hydrolytic dissociation, but in addition to this there is frequently an excess of caustic soda or potash present.



according to the nature of the second solution used), which compound increases the hardness and durability of the surface of the stone. Unfortunately, however, when calcium or barium chloride are employed, sodium chloride is also formed, and when aluminium sulphate is used, sodium sulphate is formed, and sodium chloride and sodium sulphate are the particular salts which cause the disintegration of stone in Egypt, as they find their way to the surface, where they crystallize and cause more damage than the indurating effect of the insoluble silicate formed does good.

#### 4.—*Silico-fluorides.*

Silico-fluorides, under the name of “Fluates,” have been extensively employed as stone preservatives for many years past. The most frequently used of these compounds is “Magnesia Fluates” (magnesium silico-fluoride), which is employed when the stone is calcareous, and acts by combining with the material of the stone itself, forming compounds which harden the surface of the stone and make it more resistant, but the stone is not rendered “practically waterproof,” as one advertisement claims. The use of “Magnesia Fluates” does not cause any disfiguring efflorescence.

For non-calcareous stones, such as sandstone, a preliminary treatment with another solution, called an “Avant Fluates,” is employed. A sample of “Avant Fluates” examined consisted of an alkaline solution of potassium silicate. The disadvantages arising from the use of potassium silicate have already been described.

Fluates have been tried in Egypt, but with no great success.

#### 5.—*Baryta.*

The treatment of decayed stones by baryta water is strongly advocated by Professor A. H. Church, by whom it has been employed with marked success on a number of important buildings in England. This treatment, however, is only of use in cases where either the cementing material of the stone or the stone itself contains calcium

sulphate, which may be that originally present in the stone, but more generally is that formed by the corrosive action of sulphuric acid derived from the atmosphere. The baryta acts by converting the calcium sulphate present, which is soluble in water, into barium sulphate which is insoluble, thus hardening the surface of the stone and rendering it generally more resistant to atmospheric influences, and more particularly immune against the solvent action of rain water and the corrosive action of sulphuric acid. Such an immunity, however, is not required in Egypt, where, for example, the mortar used by the ancient Egyptians for such monuments as the Pyramids at Gîza, the Sphinx, the so-called temple of the Sphinx, and also at Karnak and elsewhere, which has lasted thousands of years, consists of calcium sulphate.

Further, the Egyptian building stone, not being subject to the influence of sulphuric acid, seldom contains sufficient calcium sulphate for the baryta to act upon. The use of baryta does not give rise to any efflorescence to disfigure or damage the stone.

#### 6.—*Plaster.*

Most of the modern stone buildings in Egypt are covered with plaster, generally plaster of Paris, but sometimes cement and sand or lime and sand mixtures. This treatment with plaster has become general, partly because inferior stone, bad workmanship, and want of finish may all be covered up in this way, and partly because plaster lends itself to cheap and ready ornamentation.

The plastering of a building, however, is also a method, unintentional in most cases, of protecting the stonework, and the plaster itself may be and frequently is protected by means of oil paint. The use of plaster, although much abused in Egypt, has a legitimate place among methods for preserving soft and inferior stone from decay. For buildings of small importance, plaster with a poor quality stone may be economical, but if the plaster itself is to last, there must be an efficient damp course and also a clean rough surface for the plaster to adhere to, both of which precautions are frequently neglected. The colour of the plaster may be varied by means of a colour wash, or its life prolonged by means of oil paint.

## SUMMARY.

1.—The only true cure for the disintegration of building stone in Egypt is prevention by the use of dense hard stone containing a minimum of soluble salts, and as very few of the Egyptian limestones fulfil these conditions, sandstone or granite, or imported stone, are indicated, or at the least a careful selection of the limestone available.

2.—If the question of cost precludes the use of anything but doubtful or inferior limestone, then this may be protected by plaster or by treatment with some material which will keep out moisture. Among such materials are oil paint, linseed oil (light boiled oil thinned down with benzine being the best), and paraffin wax, either as a paste or in solution, the paste being the better of the two.

3.—An efficient damp course is always necessary, even for such structures as boundary walls.

4.—Of the special stone preservatives sold, many are quite unsuitable for Egyptian conditions, and only those of a hydrofuge (water repellent) nature are recommended. Such preservatives will almost necessarily consist of solutions of oil or wax, or both. A table is annexed showing the composition and cost of many of the stone preservatives on the market.

5.—The various preservatives mentioned are only in the nature of a palliative, they will retard disintegration, but will not entirely prevent it, and they will require periodical renewal, and in some cases will discolour or otherwise disfigure the stonework. A most important factor in conditioning the utility of a stone preservative, provided it be of the right nature, is the degree of penetration obtained, the greater the penetration the more effective being the solution. Hence a liquid condition, a dry stone, warm weather, and a spraying apparatus \* are all indicated.

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\* Small spraying apparatus of the knapsack type are very suitable.

# Stone Preservatives on the Market.

Solution.	Price Quoted.	Surface Covered.	Cost per Hundred Square Yards.	Composition.
<i>A</i>	£ s. d. 0 3 0 per gallon ...	1 gallon per 20 square yards (three coats) ... ..	£ s. d. 0 15 0	Glue in water with a little linseed oil.
<i>B</i>	14 0 0 per 40 gallons...	1 gallon per 20 square yards (three coats) ... ..	1 15 0	Linseed oil and paraffin wax in turpentine.
<i>C</i>	0 7 8½ per gallon ...	Assumed to be 1 gallon per 20 square yards ... ..	1 18 5¼	Sodium silicate.
<i>D</i>	0 9 8 " ... ..	1 gallon per 18 square yards (three coats) ... ..	2 13 8	Xylonite in amyl alcohol.
<i>E</i>	0 7 6 " ... ..	1 gallon per 10 square yards (two coats) ... ..	3 15 0	Resin and a little wax in light hydrocarbon.
<i>F</i>	0 0 1 per square foot of surface covered	1 square foot (two coats) ... ..	3 15 0	Magnesium silico-fluoride.
<i>G</i>	Slightly more than 1d. per square foot of surface covered ... ..	1 square foot ... ..	+3 15 0	Magnesium silico-fluoride plus potassium silicate.

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